JOURNAL OF RESEARCH ON TECHNOLOGY IN EDUCATION, *39*(3), 289–306

A Study of the Effectiveness of the Louisiana Algebra I Online Course

Laura M. O'Dwyer
Boston College

Rebecca Carey and Glenn Kleiman
Education Development Center, Inc.

Abstract

Student enrollment in K–12 online learning programs showed a tenfold expansion in the years between 2002 and 2005. Despite increased implementation to fulfill critical local needs, there is very little evidence-based research available to inform education leaders' decisions relating to these initiatives. To address the important question of whether online learning can be as effective as traditional face-to-face learning, this research presents the findings from a quasi-experimental design implemented to examine the effect of the Louisiana Algebra I Online initiative on student outcomes. The findings presented suggest that the Louisiana Algebra I Online model is a viable online model for providing effective Algebra I instruction. (Keywords: online learning, algebra I, virtual learning, distance learning.)

Increasing numbers of schools and districts are implementing online courses for students. Estimates of student enrollment in K–12 online learning programs show a tenfold expansion in four years, from an estimated 40,000–50,000 students during the 2001-2002 school year, to more than 520,000 in the 2004-2005 school year (McCleod, Hughes, Brown, Choi, & Maeda, 2005). In addition to helping address shortages of qualified teachers in specific subject areas and geographical regions, online learning also offers schools and districts the opportunity to broaden the variety of course offerings available to students (Perreault, Waldman, & Zhoa, 2002). These advantages are particularly salient given the current mandates of No Child Left Behind for improving student achievement and for providing all students with highly qualified teachers. Rural schools are leading the way in online course enrollment with 46% of rural districts reporting that their students were participating in distance education courses compared with 28% in urban school districts and 23% in suburban districts (Setzer & Lewis, 2005). Within the umbrella term "distance education" or "online learning" there are myriad models through which coursework can be delivered. For example, during the 2002-2003 school year, many districts reported that they used two-way videoconferencing to teach classes (55%) while others described asynchronous computer-based instruction delivered via the Internet (47%) (Setzer & Lewis, 2005). Other online models include pre-recorded video instruction, synchronous computer-based courses delivered via the Internet, or using other technologies such as teleconferencing or CD-ROM to provide instruction to students.

While online learning programs are becoming more widely used by K–12 schools and districts, there is very little evidence-based research available to guide education leaders' choice of initiative. For example, there has been very little high quality

research on the effectiveness of online learning at the high school level compared to traditional face-to-face learning, and almost no research on curriculum specific interventions. For example, in a meta-analysis of 19 research studies that examined K–12 online programs, Cavanaugh (2001) reported that there was preliminary evidence that suggests that students in online courses do as well as students who receive face-to-face instruction. However, only 10% of the studies examined by Cavanaugh employed an experimental or quasi-experimental approach. Similarly, another meta-analysis conducted by Ungerleider and Burns (2002) found that only two of the 232 studies that focused on online learning at the K–12 level met their criteria of being "empirically sound" (i.e., used experimental or quasi-experimental methods, used appropriate data analyses, and made conclusions appropriate to the methodology used).

Looking to the research that has been conducted in online learning environments in higher education settings, several studies have found that online learning programs provide students and teachers with quite different learning and teaching environments than those provided in traditional, face-to-face settings (Bernard et al., 2004; Peters, 2003; Stodel, Thompson, & MacDonald, 2006). The distinguishing characteristics include class structure (Paloff & Pratt, 2001), the level and types of peer-to-peer and student-teacher interactions that take place (Bernard et al. 2004; Lally & Barrett, 1999), and the lack of "social presence" during the learning process (Aragon, 2003; Bibeau, 2001; Garrison & Cleveland-Innes, 2005). While many studies of higher education learning outcomes have found no statistical differences in achievement for online courses compared to traditional, face-to-face courses, there remains concern that the quality and depth of learning may be affected in online courses (Allen, Bourhis, Burrell, & Mabry, 2002; Lockyer, Patterson, & Harper, 2001; Neuhauser, 2002; Thirunarayanan & Peres-Prado, 2001-2002). Mediating variables that may promote or hinder learning success in an online environment have been isolated in several studies and these include students' attitudes towards the online environment (Sherry, Fulford, & Zhang, 1998) and their beliefs about the efficacy of online learning (Cooper, 2001; Allen et al., 2002; Muilenburg & Berge, 2001; Navarro & Shoemaker, 2000; Smith & Dillon, 1999).

While much of the available research on online learning focuses on higher education settings, these studies provide us with a framework for understanding how and why student outcomes in K–12 online distance learning programs may be different from those in traditional, face-to-face courses. The current lack of sound empirical evidence about the impacts of online learning in K–12 settings is troublesome given its widespread and growing use and the costs incurred from limited school budgets to support its use. Since many online learning initiatives are implemented to fulfill critical local needs, the important question is whether online learning can be as effective as traditional, face-to-face learning. That is, do students who participate in online learning initiatives perform as well as students who participate in traditional, face-to-face courses? Also of interest is whether students in online learning programs engage in different types of peer-to-peer interactions than students in traditional courses and whether they differ in how they perceive their learning. With these questions in mind, we conducted this research to examine how

student outcomes from one particular type of K–12 online distance learning model compared with those of students in a traditional, face-to-face course.

The 2004-2005 school year implementation of the Louisiana Algebra I Online project provided a unique opportunity to use a quasi-experimental design to examine these questions. This online distance learning initiative, a program of the Louisiana Virtual School (LVS), was first implemented in 2002. During the 2004-2005 school year, 257 students from 18 intact classrooms in six school districts and two private schools participated in the initiative. Designed for schools in which a sufficient number of certified mathematics teachers were not available, the goal of the initiative was to improve educational opportunities for students by providing them with a high-quality, standards-based curriculum delivered online by a certified mathematics teacher. Additionally, this highly qualified teacher mentored a classroom teacher who was not certified to teach mathematics. The innovation of the Louisiana model is that it enables a school to have a certified teacher available when one is not locally present, while still providing students with the structure and opportunities afforded by regular class meetings.

With its large number of rural school districts in which teacher recruitment and retention remain problems, Louisiana faces a particular challenge in helping students gain proficiency in mathematics. According to Beeson and Strange (2003), 26.3% of public school students in Louisiana are enrolled in rural school districts. Of this percentage, 31.7% of the students are classified as minority students and 21.5% live in poverty. Overall, 90.5% of Louisiana's teachers were classified as "highly qualified" during the 2003-2004 school year. However, when the data are disaggregated by school poverty level, it is evident that high poverty schools in Louisiana have lower percentages of highly qualified teachers. For example, during the 2003-2004 school year, only 86.5% of the teachers were considered highly qualified in the high poverty schools, compared to the 93.1% of teachers in low poverty schools (2003-2004 Louisiana State Education Progress Report, http://www.doe.state.la.us).

THE LOUISIANA ALGEBRA I ONLINE PROJECT

Students enrolled in the Louisiana Algebra I Online program participated in an algebra class that met on a standard class schedule, with all students meeting together in a technology-equipped classroom. Each student had a multimedia, Internet-connected computer during class time where the course curriculum and materials could be accessed. Students who had access to an Internet-connected computer at home or elsewhere could access their course materials outside of the school day. Each student benefited by having two teachers: an experienced secondary certified mathematics teacher who was available online and a teacher available in the classroom who was not certified to teach mathematics. In addition to giving students access to two teachers, this approach provided a unique professional development model for the in-class teachers since they worked throughout the year with a highly qualified mathematics teacher who was available online.

The Algebra I Online course used a curriculum designed by the Louisiana Center for Educational Technology (LCET) and the Louisiana School for Math,

Science, and the Arts (LSMSA). The course was aligned to the National Council of Teachers of Mathematics (NCTM) standards and the Louisiana state content standards, benchmarks, and Grade Level Expectations (GLEs) (http://lvs.doe.state.la.us). Delivered via the *Blackboard* online learning platform, the course design incorporated e-mail, Internet tools such as Java Applets, and video into the lessons. Students also used graphing calculators and *Graphire 2 Digital Tablets*™ with a stylus and handwriting capture system. Students in the comparison classrooms received the traditional or "business as usual" approach to algebra instruction and the curriculum and textbooks used in both the treatment and comparison group classrooms addressed the same content standards and learning goals as outlined in the Louisiana GLEs (http://www.louisianaschools.net).

The online teacher served as the teacher of record for the students in the Algebra I Online classrooms and as a mentor and model to the in-class teacher. The online teachers were expected to respond to the students' questions and assignments in a timely manner, to provide feedback on homework, tests, and discussion board postings, to keep the students and the in-class teacher informed about student progress and status, maintain the schedule in the course delivery system used for the online course, provide whole group and individual communications and instruction, and stay in constant contact with the in-class teacher. The online teachers reported grades to LVS on a regular basis and maintained e-mail backups to submit to LVS three times a year.

The in-class teachers, most of whom were either certified in other areas or were working toward a secondary mathematics teaching credential, followed the curriculum guide to facilitate face-to-face learning activities and collaborated with the online teachers in guiding and supporting the students. Their responsibilities included creating an atmosphere conducive to learning in the classroom, assisting students with technology, supervising and guiding the Algebra I students through the coursework, working with students when problems arose, staying in constant contact with the online teacher, providing feedback on activity days, and proctoring tests and exams. Both the in-class and online teachers participated in workshops to prepare them for participation in the Algebra I Online initiative (Kleiman, Carey, Halsted, & O'Dwyer, 2005).

In the first year of the course delivery (2002–2003), the Southwest Educational Development Laboratory (SEDL) included the Algebra I Online course as part of a study to determine the quality and effectiveness of curriculum, instruction, and student assessment in online courses. The study reported that the Algebra I Online program "meets the criteria" of an effective and quality Web-based course for middle and high school students based on (1) alignment with state standards, (2) providing resources that enrich course content, (3) providing opportunities for students to engage in abstract thinking and critical reasoning skills, (4) providing appropriate student-to-student, as well as teacher-to-student interactions.

STUDY DESIGN AND SAMPLE CHARACTERISTICS

A quasi-experimental design was used to examine the impact of the Louisiana Algebra I Online initiative on student outcomes. Under this design, student outcomes for those receiving the treatment were compared with those of students

in matched comparison classrooms. Implemented in 18 intact classrooms in six school districts and two private schools, a total of 257 students participated in the Louisiana Algebra I Online project during the 2004-2005 school year. To enroll in the Algebra I Online program, districts were required to demonstrate a need for certified mathematics teachers and a desire to provide professional development to teachers interested in obtaining certification in secondary mathematics. District leaders were asked to identify the schools in which the program was to be implemented, the teachers who would serve as in-class teachers for the Algebra I program, and a comparison classroom.

According to the NCES 2001-02 School District Locator, four participating districts qualified as rural or small town districts and the remaining two were classified as urban fringe of mid-size city districts. All six districts had previously participated in the Algebra I Online program during the 2003-2004 school year, and two had participated in the pilot year in 2002-03. The Algebra I Online course was available to students in Grades 8 and 9 and there were no academic prerequisites for enrolling in the course. The course was not intended for those who had previously failed algebra, so regardless of grade, students were taking Algebra I for the first time. Since online learning makes certain demands upon students beyond those in face-to-face algebra courses, the districts and schools were asked to avoid selecting students on the basis of prior mathematics achievement and instead to consider students' ability to work independently and communication skills when selecting students for the Algebra I Online course. Students who were deemed eligible to participate in the project were then assigned to classrooms that would receive the intervention.

The majority of teachers who served as in-class teachers for the Algebra I Online program did not hold a secondary mathematics certification. Approximately 50% of these teachers were certified to teach elementary education and the remainder held certifications in middle school mathematics, special education, health and physical education. The average number of years teaching for the in-class teachers was 8.5, and they taught an average of five classes per semester with an average class size of 21 students.

Districts were asked to identify comparison classrooms that were similar with regard to mathematics ability, environment, and size, but where teachers used traditional "business as usual" approaches to teaching algebra. In Louisiana, the only requirement for a traditional algebra classroom is for the teachers to cover the Louisiana content standards and benchmarks, as well as the Grade Level Expectations (http://lvs.doe.state.la.us). While there was ongoing professional development on effective classroom strategies, there was no statewide mandate on how the classes should be taught. Since the comparison group teachers were not required to alter instruction it was anticipated that these classes might make use of some technologies. In fact, when survey data from the comparison classrooms were analyzed, 76.2% of students reported using technology during their traditional, face-to-face algebra course. Of these students, 83.7% said they used a graphing calculator, 9.8% said they used online simulations, 17.6% said they used spreadsheets, and 2% reported using e-mail.

Eighty-five percent of the teachers in the comparison classrooms were certified to teach secondary math. The average number of years teaching for these teachers was 11.7, and similar to the in-class participating teachers, teachers in the comparison classrooms reported teaching an average of five classes per semester with an average class size of 22 students.

The online teachers were selected on the basis of their outstanding teaching credentials and were identified by the Louisiana Department of Education to be at the level of "mentor teachers." They were master teachers who were certified to teach secondary mathematics and experienced with technology.

To assess the fidelity of the implementation of the Algebra I Online program, classroom observations were conducted in a convenience sample of the treatment group classrooms; nine of the 18 classrooms made up this convenience sample. The classroom observations documented the types of instructional phases (i.e., transition, whole group instruction/discussion, student individual work, etc.), the roles fulfilled by the in-class teacher, and types of student interactions across the treatment classrooms. Additional observational data recorded how the technologies were used and how the classrooms were set-up. With two trained observers in each of nine classrooms, the classroom observation data showed high levels of similarity among the activities being conducted across the treatment classrooms, and in each case these activities were directly linked with how the course content was presented. For example, in each of the treatment classrooms, students used technology to "analyze information," "evaluate information," and "self-assess or assess" their own work or work from classmates (Kleiman, Carey, Halsted, & O'Dwyer, 2005).

INSTRUMENTS

Three instruments were used to gather data from students in the treatment and comparison classrooms. These were (a) a pretest designed to assess general mathematics ability, (b) a posttest aligned with Louisiana's GLEs in Algebra I, and (c) a survey to gather data about students' experiences in both the traditional face-to-face course and the Algebra I Online course (Kleiman, Carey, Halsted, & O'Dwyer, 2005).

Administered in September 2004, the pretest comprised 25 multiple-choice items that assessed students' general mathematics ability and mathematics comprehension. Scores from the pretest were used to examine the equivalence of the treatment and comparison groups prior to the implementation of the Algebra I Online Project. The Cronbach's alpha estimate of reliability for the pretest was 0.70. The posttest, administered in June 2005, was also a 25-item multiple choice test but was aligned with the Algebra I Online course objectives and Louisiana's GLEs outlined by the Louisiana Department of Education. The Cronbach's alpha estimate of reliability for the posttest was 0.81.

To ensure the content validity of the posttest for assessing Algebra I learning, two mathematics educators with experience developing curriculum and assessments mapped the items on the test to the Louisiana GLE and Algebra standards, rated them for levels of difficulty, and subsequently selected 20 to represent a balanced sample of the Louisiana GLEs with varying levels of difficulty (Kleiman, Carey, Halsted, & O'Dwyer, 2005).

To examine criterion validity evidence for these assessments, the correlations between the pretest and posttest scores and students' standardized test scores (collected in spring 2005) were calculated. At grade eight, the Louisiana Educational Assessment Program (LEAP) assessment scores for students in the Algebra I Online course were compiled. Similarly at grade nine, student scores on the norm-referenced Iowa Test of Educational Development (Iowa) assessment (http://www.doe.state.la.us) were compiled. For both tests, only an overall math score was available and so it was not possible to separate the Algebra strand from the general mathematics score. Despite this, the correlations between the eighth grade LEAP data and the pretest and posttest scores were moderately strong and positive at 0.55 and 0.67, respectively. For the ninth grade Iowa data, the correlations were 0.50 and 0.55, respectively. In terms of criterion validity evidence, the magnitude and direction of the relationship suggests that scores on the pre- and posttest measures were related in a valid way to scores on the state tests.

Surveys were administered to all students to gather additional information about students' experiences and their reactions to their Algebra I courses. Due to student confidentiality concerns, students' survey responses could not be linked to individual students and their test scores. For this reason, student survey data provided only general information about student characteristics and their views about their participation in the project. A 38-item survey was administered online to students in the treatment classrooms. This instrument was designed to collect data about students' confidence levels with algebra and technology, their experience in class, their use of technology, and how they interacted with one another and their teachers.

Students in the comparison classrooms were administered a 10 item paper-and-pencil survey that was designed to collect data about the comparison group students' comfort level with algebra and technology, their experience in the class, their use of technology during their traditional, face-to-face course, and how they interacted with one another in the course.

For the treatment group, pretest achievement data were gathered from 261 students and posttest data were collected from 231 students. Of the 231 students who completed both the pretest and posttest, survey responses were collected from 213; 179 eighth grade students and 52 ninth grade students. This resulted in a survey response rate of approximately 92% in the treatment group. Within the comparison classrooms, pretest data were collected from 360 students and posttest data from 232 students. Of the 232 students that completed both the pretest and posttest, survey responses were gathered from 207 students; 91 eighth grade students and 141 ninth grade students. The resulting survey response rate in the comparison group was approximately 89%. Since students in the treatment group and comparison groups were taking Algebra I for the first time regardless of grade, data from both grades were combined for analysis.

RESULTS

In the treatment and comparison classrooms, pretest achievement data were gathered from 621 students and posttest data were collected 463 students. Since 158 students who had taken the pretest did not take the posttest, patterns of non-

Table 1: Pretest and posttest means for treatment and comparison groups

		N	Mean	Standard Deviation
Total Pretest Score	Comparison group	232	14.99	3.33
	Treatment group	231	14.91	2.88
Total Posttest Score	Comparison group	232	14.61	5.37
	Treatment group	231	15.27	4.50

completion were examined. Approximately half of the students who were missing posttest scores appeared to be missing at random within classrooms. The remaining students with missing posttest scores appeared to be from comparison group classrooms where the range of missing scores within classrooms was between 50% and 100%. The mean pretest score for all students with missing posttest scores (13.25) was statistically significantly lower than the mean for the students who had taken both the pretest and the posttest (14.90) ($t = -3.99$, $df = 146$, $p < .001$). The analyses of student outcomes presented here were conducted using only those students for whom pre- and post-invention outcomes were available for a total of 463 students.

Pretest data were used to examine the equivalence of the treatment and comparison group classrooms prior to the implementation of the intervention. With a maximum possible score of 25 points, Table 1 shows that the mean pretest score for the comparison group students was 14.99 points, and the mean for the treatment group was 14.91 points. The difference between the treatment and comparison group means on the pretest was not statistically significant ($t = 0.27$, $df = 461$, $p = 0.788$).

The mean posttest score for the comparison group was 14.61 points and the treatment group mean was 15.27 points. Similar to the pretest, the comparison group posttest scores were slightly more variable than the treatment groups' scores; 5.37 compared to 4.50.

Pre-to-posttest gain scores were not examined because the pre- and posttests were not psychometrically equivalent. Instead, a multilevel regression model in which students pretest scores were included as a covariate was used to examine the effect of the intervention on students' posttest scores. Specifically, students were modeled as nested within classrooms, and posttest scores were modeled as a function of students' pretest scores at level-1 and a dummy variable representing treatment or comparison group membership at level-2. Since the intervention was applied at the classroom level and students were nested within classrooms, this approach accounted for the hierarchical nature of the data (Raudenbush & Bryk, 2002). In total, 463 treatment and comparison group students were nested within 33 classrooms.

Prior to inclusion in the two-level model, students' pretest scores were adjusted for measurement error or unreliability (recall that the Cronbach's alpha for the pretest was 0.70). While measurement error in the pretest and/or posttest may reduce the precision of the estimate of the treatment effect; measurement error in

Table 2: Reliability-Adjusted Two-Level Model to Predict Posttest Scores

	Coefficient	St. error	p-value
Level-1 Model			
Adjusted Pretest Scores	0.74	0.08	.000
Level-2 Model			
Group Membership	1.85	1.07	.093

the pretest in particular may also introduce a bias when estimating the regression slope and in turn produce a biased estimate of the treatment effect (Shadish, Cook, & Campbell, 2002). By correcting for unreliability in the pretest measure, the regression coefficient in the multilevel model for the pretest scores was likely to be an unbiased estimate of the population regression coefficient. [1]

The results in Table 2 show the coefficients and the related significance levels for the two-level regression model that included students' adjusted pretest scores at level-1 and students' membership in a treatment or comparison classroom at level-2. The model explained approximately 30% of the variability in students' posttest scores. At level-1, the adjusted pretest scores were significant predictors of students' posttest scores ($p < 0.001$). The level-2 coefficient for the dummy variable representing membership in the treatment or comparison group (1.85) indicates a positive effect for group membership; that is, membership in the treatment group was associated with slightly higher posttest scores. However the coefficient was not statistically significant ($p = 0.093$) indicating that after controlling for scores on the pretest, group membership was not statistically significantly related to students' posttest scores. These results suggest that students in the participating Algebra I Online classrooms appear to have performed as well on the posttest as students who participated in the traditional algebra I course. This finding is similar to that reported in other studies which compared learning outcomes for online and face-to-face courses (e.g., Allen et al, 2002; Navarro & Shoemaker, 2000).

To examine whether the groups differed in terms of their responses to particular types of items on the post-intervention assessment, item-level means were compared. The treatment classrooms' mean was higher than the comparison classrooms' mean on 18 of the 25 items included on the posttest. The largest group of items (5) that assessed a single skill related to students' ability to "write an algebraic expression from a real-world example" and for each of these five items, the treatment group mean was higher than the comparison group mean. The difference between the groups was statistically significant for four of the five items. Of the seven items on which the comparison group classrooms outscored the treatment group classrooms, the difference between the comparison and treatment group means was statistically significant for only three.

[1] The adjusted pretest scores were calculated using the formula $X_{adj} = \overline{X} + r(X - \overline{X})$ where r is the reliability of the pretest measure, in this case, Cronbach's alpha. The corrections for treatment and comparison groups were made separately.

Table 3: Enjoyable Aspects of the Algebra I Online Course

	Percentage of students in treatment group agreeing that they liked this aspect of the course
Using technology to learn math	71.8%
Working with other students	68.5%
New experience	59.2%
Activity days	44.6%
Challenging material	32.9%
Having two teachers	30.5%
The pace of the course	23.9%

Table 4: Treatment Group Students Reported Difficult Aspects of the Online Algebra I Course

	Percentage of students in treatment group agreeing that this was the hardest thing about the course
Getting the assignments done on time	70.0%
Getting used to a new class structure	49.8%
Working independently	36.6%
Using the technology	15.0%

Survey responses from students in the treatment and comparison group classrooms were also compared to examine whether students in the online learning program engaged in different types of peer-to-peer interactions than students in the traditional, face-to-face course and whether they differed in how they perceived their learning. Students in the treatment group were asked several questions related to their experiences in the Louisiana Algebra I Online project. These questions related to their perception about the difficulty of the course, their experiences with the technology and the course materials, and the type and level of communication they engaged in with the in-class and online teachers. Since students in the treatment group were expected to use technology extensively throughout the course, students were asked to describe their experience level with technology before enrolling in the Algebra I Online course. The majority of treatment group students reported that they were either somewhat experienced (64.30%) or very experienced (26.80%) with technology before enrolling in this course.

When asked to identify the characteristics that they most liked about the online course, Table 3 shows that the largest percentage of students in the treatment group classrooms agreed that they liked using technology to learn math (71.8%), working with other students (68.5%), and having a new experience (59.2%). The pace of the course was the least selected characteristic (23.9%).

The students in the treatment group classrooms were asked to identify the most difficult aspect of the Algebra I course. Table 4 shows that 70% of students said

Table 5: Course Materials and Technologies Most Helpful for the Treatment Group Students

	Extremely helpful	Very helpful	Helpful	Not very helpful
Discovering Algebra Textbook	9.4%	29.6%	49.8%	11.3%
Blackboard course	20.7%	28.2%	39.0%	12.2%
E-mail	22.1%	32.4%	33.3%	12.2%
Animated tutorials	26.8%	31.9%	26.3%	15.0%
TI-83 Graphing Calculators	63.4%	19.2%	14.1%	3.3%
Graphire 2 Digital Tablet™	38.0%	30.5%	19.7%	11.7%

Table 6: Frequency of Students Asking In-Class Teachers about Content or Technology

	Every lesson	Couple of times a week	Once a week	Every couple of weeks	Never
How often did you ask your in-class teacher questions about Algebra content?	33.30%	26.30%	17.40%	18.30%	4.70%
How often did you ask your in-class teacher questions about technology?	6.60%	12.20%	16.90%	37.60%	28.80%
Frequency of the communication with the online teacher?	44.60%	27.70%	12.20%	6.60%	8.90%

they found that getting their assignments done on time was the most difficult. While about half the students reported finding it difficult to get used to the new class structure, only 15% reported that using the technology was the most challenging aspect. The online format likely required more independent work than a traditional face-to-face course and only about one-third of the students reported having difficulty working independently.

The treatment group was also administered survey items to gather information about their experiences with the course materials and technologies that were most helpful to them in learning algebra. Table 5 shows that the majority of treatment group students identified the TI-83 graphing calculator as being the most helpful; 82.6% of treatment group students said that the graphing calculator was either very helpful or extremely helpful. The *Graphire 2 Digital Tablet*, the animated tutorials, and e-mail were also identified as being very or extremely helpful by the students in the treatment group classrooms.

To investigate the role of the in-class teacher, the students in the treatment group classrooms were asked how often they approach their in-class teacher with content or technology questions. Table 6 shows that more than half (59.6%) the students

Table 7: Student Responses to the Question "Did the Course Provide a Good Learning Experience?"

	Yes	Satisfactory	No
Comparison Group Students	62.80%	30.90%	6.30%
Treatment Group Students	38.50%	40.80%	20.70%

in the treatment group classrooms reported asking their in-class teacher about the algebra content either a couple of times a week or every lesson. Conversely, a smaller percentage of students reported asking their in-class teachers about technology more than once a week; more than half the students in the treatment group classrooms (64.4%) reported asking their in-class teacher questions about technology either "never" or "every couple of weeks." Table 6 also shows that almost half (44.6%) of the treatment group students said that they communicated with their online teacher during every lesson. Fewer than 9% of treatment group students reported that they almost never had e-mail communication with their online teacher.

On a similar note, the students in the treatment group classrooms were asked to share their perceptions about the adequacy of the interaction between them and the online teacher. When asked whether the online teacher-student interaction was adequate for their needs, only 38% of the treatment group students said that the interaction was adequate. When asked how helpful their online teacher was for understanding algebra, approximately three-quarters of treatment group students said that the online teacher was either "extremely helpful," "very helpful," or "helpful."

Several common survey items were administered to the treatment and comparison group students to examine their Algebra I learning experiences. Table 7 shows that the majority of students in both groups reported that they had a good or satisfactory learning experience in their respective Algebra I courses. A higher percentage of treatment group students reported that they did not have a good learning experience; 20.70% in the treatment group compared to 6.30% in the comparison group. While these findings are similar to those of Allen, Bourhis, Burrell, and Mabry (2002) who found that not all students were satisfied with their online learning experiences or place a similar value on online learning, other studies have found that students in online and traditional settings have similar levels of satisfaction with their learning experience (Cooper, 2001; Smith & Dillon, 1999).

As Table 8 shows, a higher percentage of students in the comparison classrooms reported feeling either confident or very confident in their algebra skills after taking this course (67.6%) compared to the students from the treatment group classrooms (49.8%). While this finding is interesting given that students in the treatment classrooms had a mean posttest score that was similar to the mean in the comparison classrooms, it is consistent with the findings from other studies that suggest that students in online learning courses may have poorer perceptions of their learning (Bernard et al., 2004). The data also show that the students in the treatment group classrooms reported higher rates of feeling either confident or very confident in their technology skills after taking this course (79.8%) than did the

Table 8: Student Confidence in their Algebra and Technology Skills

		Very Confident	Confident	Somewhat Confident	Not confident at all
Student confidence in algebra skills	Treatment	11.30%	38.50%	39.40%	10.80%
	Comparison	20.30%	47.30%	28.50%	3.90%
Student confidence in technology skills	Treatment	41.80%	38.00%	17.80%	2.30%
	Comparison	13.60%	48.50%	34.00%	3.90%

Table 9: Student Interaction in Treatment and Comparison Classrooms

	Treatment Group Students	Comparison Group Students
To talk about the math in the course	84.0%	68.0%
To talk about the technology	55.9%	Not asked
To socialize	62.4%	64.1%
To understand assignment directions	71.4%	67.7%
To work together on in-class assignments	70.9%	70.1%
To work together on homework	55.9%	51.5%
To work together on activities	86.9%	60.9%

students from the comparison group (62.1%). This is not surprising considering the online nature of the course.

Examination of peer-to-peer interactions was deemed important because the lack of "social presence" during the learning process has been found to be an important mediating variable for learning and attitudinal outcomes (Aragon, 2003; Bibeau, 2001; Garrison & Cleveland-Innes, 2005). For this reason, students in both groups were asked about the circumstances under which they interacted with other students in their Algebra I classroom. As the results in Table 9 show, the students in the comparison classrooms reported spending less time interacting with other students to talk about the math in the course; 68% in the comparison classrooms compared to 84% in the treatment classrooms. The comparison group students also spent less time working together on activities than the students in treatment group classrooms; 60.9% compared to 86.9%. The amount of time spent socializing, interacting to understand assignment directions, and working together on both in-class assignments and homework were approximately equivalent across the two groups. It would appear from the data that there was no perceived lack of "social presence" among the treatment group students. This may have been due to the hybrid nature of the course, whereby students benefited from meeting on a regular class schedule with an in-class teacher and their peers while also having access to a highly-qualified teacher online.

DISCUSSION AND CONCLUSIONS

The Louisiana Algebra I Online model was designed and implemented to bring highly qualified mathematics teachers to students in places where they would not be otherwise available, to provide students with the structure of a regular class period, and to provide a unique professional development model for local teachers. To address the critical need for evidence-based research to inform the proliferation of online distance learning initiatives, this paper described a quasi-experiment that was conducted to examine the effect of one particular model for online learning at the high-school level on student performance; namely, the Louisiana Algebra I Online model. To complement the learning outcomes, survey responses from students in the treatment and comparison group classrooms were examined. Recognizing that content delivery methods (online versus traditional, face-to-face delivery) should not hinder student learning, it was important for us to understand the experiences of students in the treatment and comparison classrooms during their participation in the Algebra I Online course (Bernard et al., 2004; Paloff & Pratt, 2001; Peters, 2003; Stodel, Thompson, & MacDonald, 2006).

The survey data showed that the students in the treatment classrooms appeared to have had adequate access to technology, enjoyed using technology to learn math, and enjoyed the new learning experience. The students identified the characteristics of the Algebra I Online course that were most helpful to them in learning algebra and these included graphing calculators, *Graphire 2 Digital Tablet* hardware, as well as the animated tutorials and e-mail communications. The data showed that in terms of implementation, the project was successful in providing adequate and reliable technology access to those students participating in the course. Also, with the majority of students reporting that they liked to use technology to learn mathematics, students in the treatment classrooms appear to have responded positively to the online learning environment in which the mathematics content was presented.

The Algebra I Online model also required changes to the type and level of interaction between students and teachers, and among the students in the class. The majority of students in the treatment classrooms felt that the interaction with their online teacher was somewhat less than adequate or should have been a lot more. With regard to peer-to-peer interactions, the students in the treatment classrooms reported spending more time interacting with other students to talk about the content of the course and working together on course activities. The amount of time spent socializing, interacting to understand assignment directions, and working together on both in-class assignments and homework were approximately equivalent across the two groups. The types of interactions among the students in the treatment classrooms appear to contradict the commonly held concern that students in K–12 online classes will not remain on task. As studies in higher education have shown, online programs can often isolate students during the learning process (e.g., Bernard et al. 2004; Lally & Barrett, 1999). While the Louisiana Online Algebra I program is unusual in that it provides students with the benefit of a regular class schedule where they interact with their peers as well as an online teacher, other emerging K–12 online models may not provide such opportunities for important socio-academic interactions. As more K–12 online

distance learning models emerge, the ways in which peer-to-peer interactions manifest will no doubt continue to evolve and studies of these interactions should be undertaken. This is particularly important given the important role that social interaction plays during the K–12 years.

When compared to the comparison group students, a higher percentage of students in the treatment group classrooms reported that they did not have a good learning experience. Considering the same content standards were covered in both groups, the difference in learning experience may have been a function of the newness of the online model, specific differences in the curricula, and/or differences in classroom approaches. Although some studies in higher education settings have found there to be no difference between students' level of satisfaction in online and traditional courses (Cooper, 2001; Smith & Dillon, 1999), other studies point to fundamental differences between the learning experiences that lead some students to be less satisfied with their online experience (Allen, Bourhis, Burrell, & Mabry, 2002). Similarly, students in the treatment and control classrooms differed with respect to their confidence in their algebra skills. Despite having similar posttest means, compared to the comparison group, a lower percentage of students in the treatment classrooms reported feeling either confident or very confident in their algebra skills after the course. This finding supports those from studies described by Bernard et al (2004) in their meta-analysis on how online and traditional classroom experiences vary. It may be that the model of delayed feedback and dispersed authority in the online course led to a "lost" feeling where students could gauge "how they were doing." There is currently a lack of research on the mediating or moderating effect of student satisfaction and confidence levels on learning outcomes in K–12 settings. Given the importance of student attitudes and beliefs for moderating learning outcomes in traditional, face-to-face learning environments (Koretz, McCaffrey, & Sullivan, 2001; O'Dwyer, 2005), future research into the effectiveness of online or distance learning initiatives in K–12 settings should pay particular attention to student satisfaction and other affective measures.

Despite their feeling less confident in their algebra skills, the data showed that students in the treatment classrooms outscored the comparison classrooms on 18 of the 25 items on the posttest. The data also showed that students in the treatment classrooms tended to do better than students in the comparison classrooms on the group of items that required them to create an algebraic expression from a real-world example. Bearing in mind that the content standards covered in both courses was the same, the differential effect of the online distance learning initiative on particular types of algebra skills should be explored further. It may be that students in the treatment classrooms acquired better conceptual understanding of some aspects of the content due to the nature of the technology-enhanced teaching tools employed. Further research would need to be conducted to substantiate this hypothesis. Overall, students in the treatment group performed as well as students in the comparison face-to-face classrooms. While this finding is similar to that reported in other studies that compared learning outcomes (Allen et al, 2002; Navarro & Shoemaker, 2000), more research is needed at the K–12 level to examine this important issue. With more than half a million elementary, middle and high school students impacted by some form of online learning initiative

during the 2004-2005 school year, it is vital that the educational community and in particular state and local decision-makers have access to high-quality research they can use to inform their ongoing investments in online learning initiatives.

Although there are many types of online and distance learning models available for schools and districts, the results of this research suggest that the Louisiana Algebra I Online model is a viable approach to providing Algebra I instruction, particularly when a certified mathematics teacher is not available locally. With the recent increase in investments for online distance learning initiatives at the K–12 level, there will be a continuing need for sound empirical evidence about the effect of these programs on teaching and learning outcomes, and in particular on student performance.

Contributors

Laura O'Dwyer is an assistant professor at the Lynch School of Education at Boston College. Her research focuses on examining the effects of organizational characteristics on individual outcomes, international comparative studies, and educational technology as a teaching and learning tool. (Address: Laura M. O'Dwyer, Assistant Professor, Educational Research, Measurement and Evaluation Department, Lynch School of Education, Boston College; odwyerl@bc.edu; 617. 552 .8089.)

Rebecca Carey is a project director in the Northeast and Islands Regional Laboratory and the Center for Online Professional Education. Her research focuses on applied research in educational technology, specifically online education for students and adults.

Glenn Kleiman is vice president of Education Development Center, Inc., director of the EDC Center for Online Professional Education, and co-director of the Regional Education Laboratory for the Northeast and Islands Region. His work focuses on applied research to inform policy and program decisions about educational innovations. (EDC, 55 Chapel Street, Newton, MA 02458-1060; rcarey@edc.org and GKleiman@edc.org; 617.969.7100.)

References

Allen, M., Bourhis, J., Burrell, N., & Mabry, E. (2002). Comparing student satisfaction with distance education to traditional classrooms in higher education: A meta-analysis. *American Journal of Distance Education, 16*(2), 83–97.

Aragon, S. R. (2003). Creating social presence in online environments. *New Directions for Adult and Continuing Education, 100,* 57–68.

Beeson, E., & Strange, M. (2003). *Why rural matters 2003: The continuing need for every state to take action on rural education*. Washington, DC: Poverty & Race Research Action Council. Retrieved September 13, 2005, from http://www.ruraledu.org/streport/streport.html

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L.,Wallet, P. A., Fiset, M. & Huang, B. (2004). How does distance education compare to classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research, 74*(3), 379–439.

Bibeau, S. (2001). Social presence, isolation, and connectedness in online teaching and learning. From the literature to real life. *Journal of Instruction Delivery Systems, 15*(3), 35–39.

Cavanaugh, C. (2001). The effectiveness of interactive distance education technologies in K–12 learning: A meta-analysis [Electronic Version]. *International Journal of Educational Telecommunications, 17*(1), 73–88. Retrieved September 13, 2005, from http://www.unf.edu/~ccavanau/CavanaughIJET01.pdf.

Cooper, L.W. (2001). A comparison of online and traditional computer applications classes. *Technological Horizons in Education, 28*(8), 52–58.

Garrison, D. R., & Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: Interaction is not enough. *American Journal of Distance Education, 19*(3), 133–148.

Kleiman, G., Carey, R., Halsted, E., & O'Dwyer, L.M. (2005) *A study of the effectiveness of the Louisiana algebra I online project final report.* Boston, MA: Center for Online Professional Education, Educational Development Center.

Koretz, D., McCaffrey, D., & Sullivan, T. (2001). Predicting variations in mathematics performance in four countries using TIMSS. *Education Policy Analysis Archives, 9*. Retrieved September 7, 2001 from http://epaa.asu.edu/epaa/v9n34/

Lally, V., & Barrett, E. (1999). Building a learning community online: Towards socio-academic interaction. *Research Papers in Education, 14*(2), 147–163.

Lockyer, L., Patterson, J., & Harper, B. (2001). ICT in higher education: Evaluating outcomes for health education. *Journal of Computer Assisted Learning, 17*, 275–283.

McLeod, S., Hughes, J. E., Brown, R., Choi, J., & Maeda, Y. (2005). *Algebra achievement in virtual and traditional schools.* Naperville, IL: North Central Regional Educational Laboratory, Learning Point Associates, United States Department of Education. Available at http://www.ncrel.org

Muilenburg, L., & Berge, Z. L. (2001). Barriers to distance education: A factor-analytic study. *American Journal of Distance Education, 15*(2), 7–22.

National Center for Education Statistics. (2002). *Distance education course for public education and secondary school students: 2002.* Washington, DC: Institute of Education Sciences, National Center for Education Statistics. Retrieved September 13, 2005, from http://nces.ed.gov/surveys/frss/publications/2005010/

Navarro, P., & Shoemaker, J. (2000). Performance and perceptions of distance learners in cyberspace. *American Journal of Distance Education, 14*(2), 15–35.

Neuhauser, C. (2002). Learning style and effectiveness of online and face-to-face instruction. *American Journal of Distance Education, 16*(2), 99–113.

O'Dwyer, L.M. (2005). Examining the variability of mathematics performance and its correlates using data from TIMSS '95 and TIMSS '99. *Educational Research and Evaluation. 11*(2), 155–177.

Paloff, R. M., & Pratt, K. (2001). *Lessons from the cyberspace classroom: The realities of online teaching.* San Francisco: Jossey-Bass.

Perreault, H., Waldman, L., & Zhao, M. A. J. (2002). Overcoming barriers to successful delivery of distance learning courses. *Journal of Education for Business, 77*(6), 313–318.

Peters, O. (2003). Learning with new media in distance education. In M. G. Moore & W. G. Anderson (Eds.), *Handbook of distance education* (pp. 87–112). Mahwah, NJ: Erlbaum.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Thirunarayanan, M. O., & Peres-Prado, A. (2001-2002). Comparing web-based and classroom based learning: A quantitative study. *Journal of Research on Technology in Education, 34*(2), 131–137.

Setzer, J. C., & Lewis, L. (2005). *Distance Education Courses for Public Elementary and Secondary School Students: 2002–03* (NCES 2005–010). U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Shadish, W.R., Cook, T.D., & Campbell, D.T. (2002). *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston: Houghton-Mifflin.

Sherry, A. C., Fulford, C. P., & Zhang, S. (1998). Assessing distance learners' satisfaction with instruction: A quantitative and qualitative measure. *American Journal of Distance Education, 12*(3), 4–28.

Smith, P. L., & Dillon, C. L. (1999). Comparing distance learning and classroom learning: Conceptual considerations. *American Journal of Distance Education, 13*(2), 6–23.

Stodel, E.J., Thompson, T.L. & MacDonald, C.J. (2006). Learners' perspectives on what is missing from online learning: Interpretations through the community of inquiry framework. *The International Review of Research in Open and Distance Learning, 7*(3). Retrieved electronically on January 16, 2007 from http://www.irrodl.org/index.php/irrodl/article/view/325/743

Ungerleider, C. S., & Burns, T. C. (2002). *Information and communication technologies in elementary and secondary education: A state of the art review.* Paper presented at the Pan-Canadian Education Research Agenda Symposium, Montreal, Quebec. Retrieved September 12, 2005, from http://www.cesc.ca/pceradocs/2002/papers/CUngerleider_OEN.pdf